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Use of overhead transparency sheet as a heavy ion track detector

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Abstract : We have carried out measurements on overhead projector transparency (OPT) sheets in order to study its use as a heavy ion track detector The fission fragment tracks have been etched in NaOH solutions of varying normality at different temperatures in the range from 50°C–70°C. The results are presented in this paper

Keywords : Track detector, overhead projector transparency sheets, etching, track diameter, fission fragments

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In an earlier paper, Ghosh *et al* [1], had subjected overhead projector transparency sheets (OPT) to some studies in order to characterize it as a track detector. They determined the elemental composition and found it to be a triacetate. The optimum etching conditions were arrived at and the bulk etch rate V_b and the activation energy E_a were measured. They used 14.5 MeV/u and 5.9 MeV/u ^{132}Xe ions as well as ^{252}Cf fission fragments for these studies. Subsequently, Basu *et al* [2] observed α particles and fission fragment tracks in a particular type of OPT film. The fission tracks were quite distinguishable with larger diameters as compared to the α particle tracks. In a more recently reported work [3], they experimented with yet another type of OPT sheet and measured the diameter distributions and V_t/V_b ratios for the two types of OPT films.

We have made similar measurements on a locally available OPT sheet, using ^{252}Cf fission fragments. The OPT sheets used in the present studies were Garware make with a thickness of 100 μm. Pieces of dimensions 2 cm x 1 cm were cut from the sheets. They were exposed to alpha particles from ^{241}Am source and to alpha particles and fission fragments from the ^{252}Cf source for about 30 minutes at normal incidence. The detector sheets were etched in a constant temperature water bath [4]. We have used NaOH etchant with concentrations of 4*N*, 5*N*, 6*N* and 7*N*. These etchings were carried out at 70 ± 1°C. At 6*N* concentration, different temperatures were used for the etching, for the purpose of determination of the activation energy. The etching was carried out for 3 hours, 6 hours and 9 hours. After each etching, the track diameter distributions were measured using a Carl Zeiss Research microscope. A suitable magnification was used whereby an accuracy of 0.25 μm was obtained in the diameter measurements. For determining the bulk etch rate, un-irradiated detector sheets were etched for 3 hours, 6 hours and 9 hours and the masses measured using a sensitive electronic balance. The bulk etch rates were calculated therefrom.

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The value of the bulk etch rates obtained from the mass measurements are given in Table 1 for different etchant concentrations at 70°C and in Table 2 for various temperatures of etching for 6*N* NaOH etchant.

Table 1. Bulk etch rate variation with NaOH concentration (at 70°C)

Etchant concentration	Bulk etch rate (V_b) – μm/hour
4 *N*	1.13
5 *N*	1.37
6 *N*	1.75
7 *N*	2.70

Table 2. Bulk etch rate variation with temperature of etching for 6*N* NaOH

Temperature of etching (°C)	Bulk etch rate (V_b) – μm/hour
50	0.35
60	0.68
70	1.75
80	5.00

Figure 1 gives a plot of log V_b *vs* $1/T$. This is a straight line. From the slope of this line, the activation energy E_a for bulk etching is calculated to be 103 kJ mol^{-1} compared to the value of 59.3 kJ mol^{-1} obtained by Ghosh *et al* [1] earlier for a different brand of OPT.

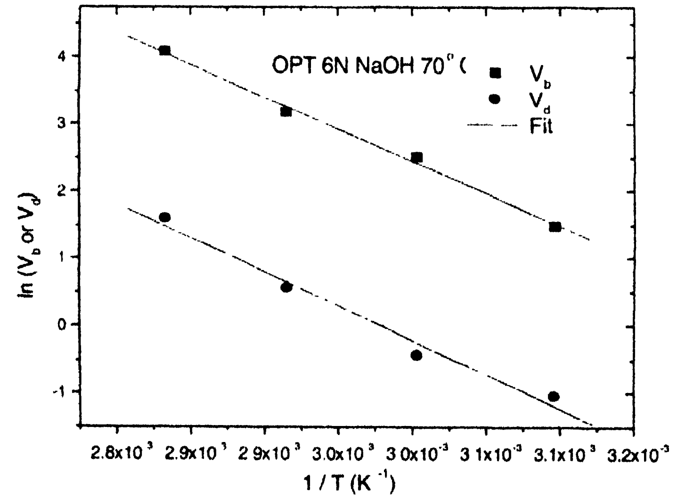

Figure 1. Variation of bulk etch rate and velocity of track diameter evolution *vs* $1/T$.

Examination of the etched, irradiated sheets showed conclusively that these sheets are insensitive to alpha particles of the energies used (upto 6.11 MeV). The sheets irradiated with ^{241}Am alpha particles also did not yield any etchable tracks.

Figure 2 gives the diameter distribution of the etched tracks for fission fragments for etching times of 3 hours, 6 hours and 9 hours. The etching conditions were 6*N* NaOH at 70°C.

Figure 3 shows the diameter distributions for 6*N* NaOH for 6 hours of etching at various temperatures from 50°C to 80°C and Figure 4 for NaOH concentrations of 4*N*, 5*N*, 6*N* and 7*N* at 70°C. All the distributions show a

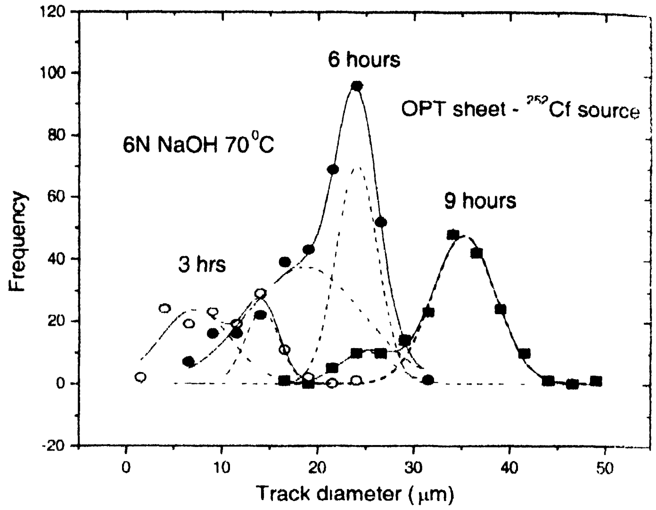

Figure 2. Track diameter distribution for ^{252}Cf fission fragments in OPT sheets for different etching times (Etchant : 6*N* NaOH at 70°C)

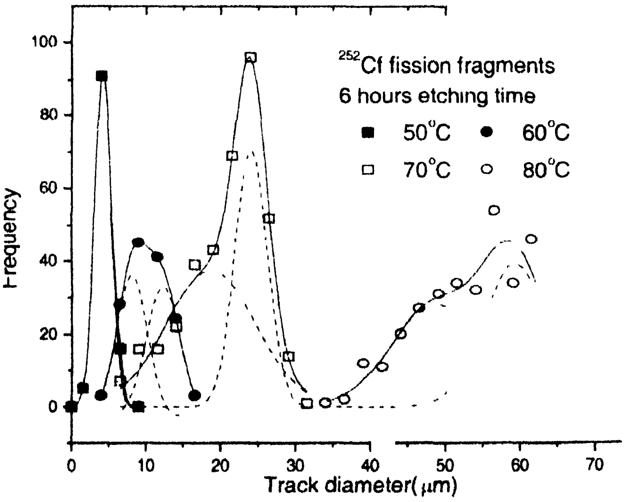

Figure 3. Track diameter distribution for ^{252}Cf fission fragments in OPT sheets after 6 hours of etching in 6*N* NaOH at various temperatures

characteristic double peaked structure, most probably corresponding to the double humped mass distribution of the fission fragments. The lower peak cannot be due to 6.11 MeV alphas since their number far exceeds that of the fission fragments. Simple two peak Gaussian fitting was attempted. The results are indicated in the above plots by the solid curves for the fit and by the dashed curves for the individual peaks.

From the Figures 2 and 3, we have extracted the velocity of track diameter evolution (V_d) at the higher maximum. These values have been also plotted in Figure 1 as a function of $1/T$ for 6 hours of etching in $6N$ NaOH. An effective activation energy for track etching the detector surface has been extracted from the plot. The value is 79 kJ mol^{-1}.

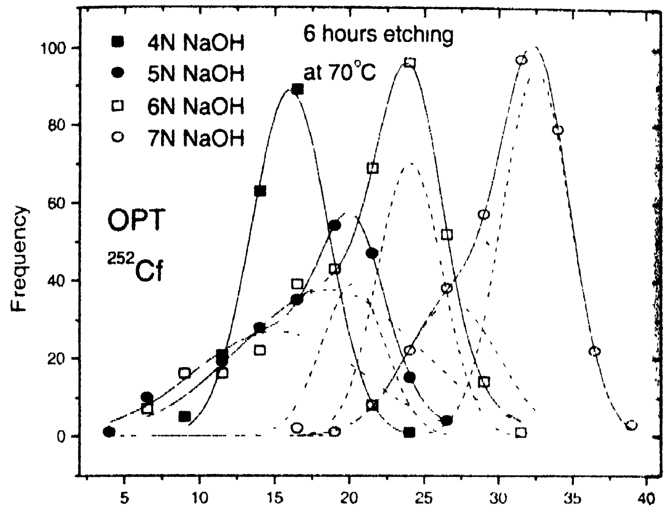

Figure 4. Track diameter distribution for ^{252}Cf fission fragments in OPT sheets etched in NaOH of various concentrations at 70°C

We have also compared the performance of the OPT sheets with that of CR-39 for fission fragments. It has been reported by Green *et al* [5] that the optimum conditions for track etching in CR-39 are 6N NaOH at 70°C. Figure 5 shows the track diameter distribution for the CR-39 detector, for the above etching conditions of $6N$ NaOH at 70°C, but for 10 hours of etching. Comparison with Figure 2 for OPT sheet reveals the better performance of the OPT sheets. However, the OPT sheets show interfering background for large etching times. In comparison, the etched tracks in CR-39 stand out against a clear background even at large etching times.

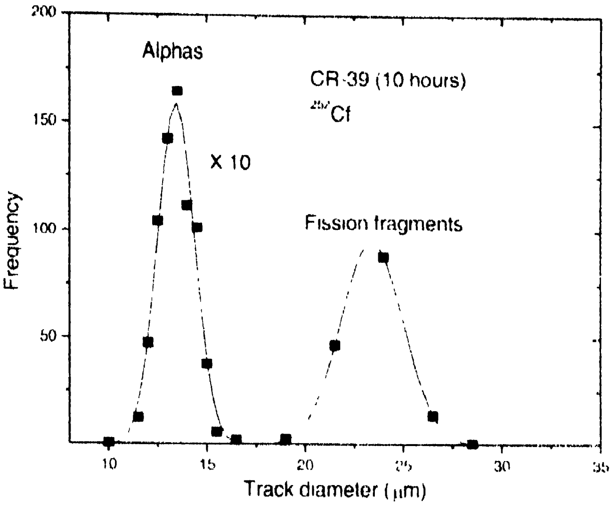

Figure 5. Track diameter distribution for alphas and ^{252}Cf fission fragments in CR-39 sheets etched using $6N$ NaOH at 70°C

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